

[0072] FIG. 23 is a flow chart of the hand part identification algorithm;

[0073] FIG. 24 is a Voronoi cell diagram constructed around hand part attractor points;

[0074] FIG. 25A is a plot of orientation weighting factor for right thumb, right inner palm, and left outer palm versus contact orientation;

[0075] FIG. 25B is a plot of thumb size factor versus contact size;

[0076] FIG. 25C is a plot of palm size factor versus ratio of total contact proximity to contact eccentricity;

[0077] FIG. 25D is a plot of palm separation factor versus distance between a contact and its nearest neighbor contact;

[0078] FIG. 26 is a flow chart of the thumb presence verification algorithm;

[0079] FIG. 27 is a flow chart of an alternative hand part identification algorithm;

[0080] FIG. 28 is a flow chart of the pen grip detection process;

[0081] FIG. 29 is a flow chart of the hand identification algorithm;

[0082] FIGS. 30A-C show three different hand partition hypotheses for a fixed arrangement of surface contacts;

[0083] FIG. 31A is a plot of the hand clutching direction factor versus horizontal hand velocity;

[0084] FIG. 31B is a plot of the handedness factor versus vertical position of outermost finger relative to next outermost;

[0085] FIG. 31C is a plot of the palm cohesion factor versus maximum horizontal separation between palm contacts within a hand;

[0086] FIG. 32 is a plot of the inner finger angle factor versus the angle between the innermost and next innermost finger contacts;

[0087] FIG. 33 is a plot of the inter-hand separation factor versus the estimated distance between the right thumb and left thumb;

[0088] FIG. 34 is a flow chart of hand motion component extraction;

[0089] FIG. 35 is a diagram of typical finger trajectories when hand is contracting;

[0090] FIG. 36 is a flow chart of radial and angular hand velocity extraction;

[0091] FIG. 37 is a flow chart showing extraction of translational hand velocity components;

[0092] FIG. 38 is a flow chart of differential hand pressure extraction;

[0093] FIG. 39A is a flow chart of the finger synchronization detection loop;

[0094] FIG. 39B is a flow chart of chord tap detection;

[0095] FIG. 40A is a flow chart of the chord motion recognition loop;

[0096] FIG. 40B is a flow chart of chord motion event generation;

[0097] FIG. 41 is a flow chart of key layout morphing;

[0098] FIG. 42 is a flow chart of the keypress detection loop;

[0099] FIG. 43A is a flow chart of the keypress acceptance and transmission loop; and

[0100] FIG. 43B is a flow chart of typematic emulation.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0101] Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0102] FIG. 1 is a system block diagram of the entire integrated manual input apparatus. Sensors embedded in the multi-touch surface 2 detect proximity of entire flattened hands 4, fingertips, thumbs, palms, and other conductive touch devices to the surface 2. In a preferred embodiment, the surface is large enough to comfortably accommodate both hands 4 and is arched to reduce forearm pronation.

[0103] In alternative embodiments the multi-touch surface 2 may be large enough to accommodate motion of one hand, but may be flexible so it can be fitted to an armrest or clothing.

[0104] Electronic scanning hardware 6 controls and reads from each proximity sensor of a sensor array. A calibration module 8 constructs a raw proximity image from a complete scan of the sensor array and subtracts off any background sensor offsets. The background sensor offsets can simply be a proximity image taken when nothing is touching the surface.

[0105] The offset-corrected proximity image is then passed on to the contact tracking and identification module 10, which segments the image into distinguishable hand-surface contacts, tracks and identifies them as they move through successive images.

[0106] The paths of identified contacts are passed on to a typing recognizer module 12, finger synchronization detection module 14, motion component extraction module 16, and pen grip detection module 17, which contain software algorithms to distinguish hand configurations and respond to detected hand motions.

[0107] The typing recognizer module 12 responds to quick presses and releases of fingers which are largely asynchronous with respect to the activity of other fingers on the same hand. It attempts to find the key region nearest to the location of each finger tap and forwards the key symbols or commands associated with the nearest key region to the communication interface module 20.

[0108] The finger synchronization detector 14 checks the finger activity within a hand for simultaneous presses or releases of a subset of fingers. When such simultaneous activity is detected, it signals the typing recognizer to ignore or cancel keystroke processing for fingers contained in the